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Technical note

Flexor digitorum brevis tendon transfer to the flexor digitorum longus tendon according to Valtin in posttraumatic flexible claw toe deformity due to extrinsic toe flexor shortening

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ABSTRACT

Claw toe deformity after posterior leg compartment syndrome is rare but incapacitating. When the mechanism is flexor digitorum longus (FDL) shortening due to ischemic contracture of the muscle after posterior leg syndrome, a good treatment option is the Valtin procedure in which the flexor digitorum brevis (FDB) is transferred to the FDL after FDL tenotomy. The Valtin procedure reduces the deformity by lengthening and reactivating the FDL. Here, we report the outcomes of FDB to FDL transfer according to Valtin in 10 patients with posttraumatic claw toe deformity treated a mean of 34 months after the injury. Toe flexion was restored in all 10 patients, with no claw toe deformity even during dorsiflexion of the ankle.

1. Introduction

Claw toe deformity (CTD) is characterised by bending of the toes in the standing position, with plantar flexion of the proximal interphalangeal (PIP) joint. The distal interphalangeal (DIP) joint may be straight, hyperextended (hammer toe deformity), or in plantar flexion (curled claw toe deformity). The deformity may be either flexible and reducible or fixed and irreducible.

When CTD develops after an injury, the most common mechanism is ischemic contracture of the muscle belly of the flexor digitorum longus (FDL) and flexor hallucis longus (FHL) after deep posterior leg compartment syndrome. [1–5], whose clinical expression differs from that of anterior leg compartment syndrome. Thus, the condition is usually painless and progresses over several months, with the gradual development of curled CTD. This form of CTD becomes apparent or worsens upon dorsiflexion of the ankle and resolves gradually as the ankle is moved into plantar flexion. These features are characteristic of extrinsic CTD and constitute the most suggestive clue to the diagnosis.

The objectives of this work were to evaluate the management of curled CTD without intrinsic muscle palsy, occurring as a sequela of trauma to the lower limb; and to describe the surgical technique developed by Valtin and Leemrijse [1,2], in which the flexor digitorum brevis (FDB) tendon is transferred to the FDL to lengthen this last tendon.

2. Operative technique

The patient is supine with a pneumatic tourniquet at the root of the ankle. A straight 3-cm long incision is made on the side of the largest webspace, from the metatarsophalangeal (MTP) joint to the middle third of the second phalanx (P2). The position of the incision is dorsomedial on the second toe and dorsolateral on the third to fifth toes, at the junction between the dorsal and plantar skin. After incision of the skin, the phalanx is followed towards its plantar aspect to the flexor tendon sheath. A scalpel is used to open the sheath along 10 to 15 mm. The FDL tendon (perforating) and FDB tendon (perforated) are identified. Care is taken to obtain good exposure of these two tendons, most notably of the two distal FDB slips inserted on the lateral aspects of the middle third of P2. The pulley system is opened over the MTP joint to expose the FDB (superficial) and FDL (deep). In doubtful cases, traction is applied to the deep tendon to check that this manoeuvre flexes the DIP (when the PIP and MTP joints are held straight), whereas traction of the superficial tendon has no effect on DIP joint balance. It is often easiest to start by dividing the FDL tendon, at its middle segment, over the MTP joint. The distal FDL stump, inserted on the base of P3, is prepared using a Kessler grasping stitch. The two FDB slips are detached from P2, yielding a proximal FDB stump and a distal

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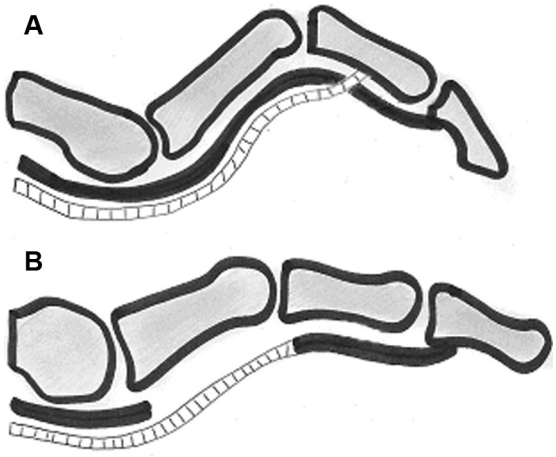

Fig. 1. A and B. Transfer of the flexor digitorum brevis (FDB) tendon to the flexor digitorum longus (FDL) tendon. Dashed line: FDB. A single lateral slip is shown. Solid line: FDL.

FDL stump. Non-absorbable monofilament suture is used to perform end-to-end anastomosis of the two stumps at the level of the split into the two terminal slips, in a square configuration, thus completing the Kessler grasping stitch. The anastomosis is then strengthened by side-to-side stitching of each of the two FDB slips to the lateral edges of the FDL tendon. Length is calibrated by keeping the toe straight and the ankle at 90° of flexion during suturing. Excessively tight suturing carries a risk of persistent CTD, whereas excessively loose suturing limits the range of active plantar flexion (Fig. 1). At the end of the procedure, the pulley is sutured using two simple stitches, taking care that no impingement occurs between the pulley and anastomosis along the full range of motion of the tendon. In patients with irreducible hallux CTD, arthrodesis of the interphalangeal joint is performed also.

After surgery, a dressing holding the toes together was fashioned to ensure immobilisation. Weight bearing was allowed, with insoles designed to prevent the rolling motion of the foot while walking, for at least 8 days when only the lesser rays were treated and for 6 weeks when arthrodesis of the hallux interphalangeal joint was performed. The dressing was changed three times a week, at home. The patients were re-evaluated after 6 weeks, 3 months, and in the long-term.

3. Patients

Ten patients with flexible CTD after posterior leg compartment syndrome were managed in our departments (Table 1). There were 6 males and 4 females, with a mean age of 30 years and 3 months (range, 16–69 years) and a mean time since the initial injury of 34 months (range, 1–7 years). All 10 patients had CTD of the four lesser toes and 6 also had hallux CTD. In most patients, the CTD developed after an isolated deep posterior leg compartment syndrome or as a sequela of compartment syndrome treated by fasciotomy with subsequent muscle recovery in the anterior, lateral, and superficial posterior compartments but not the deep posterior compartment (Table 1). Intrinsic muscle function was normal in all 10 patients, with normal flexion of the MTP and interphalangeal joints in plantar flexion (Fig. 2).

In all 10 patients, FDB to FDL transfer was performed for the lesser toes. No additional procedures on the MTP or interphalangeal joints were needed to achieve release or fusion. The 6 patients with irreducible hallux CTD underwent interphalangeal arthrodesis.

Median time to re-evaluation was 22.2 months (range, 6–36 months). All 10 patients were satisfied with the outcome and reported that they walked normally with no pain and wore normal shoes with no discomfort. The physical examination showed

Table 1
Details on the 10 patients with post-traumatic claw toe deformities.

Patient	Age	Sex	Initial trauma	Toes involved (1 = hallux)	Time to surgery	Procedure	Complications	Outcome/Follow-up
1	28	F	Rupture of posterior tibial artery (Ehlers Danlos syndrome)	2 to 5	7 years	FDB/FDL transfer 2345 Extensor lengthening 45	Delayed healing of extensor lengthening	M_1 M_4 weight-bearing callus alleviated by insole at 10 months
2	21	H	Ankle dislocation Fracture of the talus Fracture of the femur	1 to 5	12 months	FDB/FDL transfer 2345 IP_1 arthrodesis	0	Very good at 6 years
3	69	F	Leg injury	1 to 5	27 months	FDB/FDL transfer 2345 IP_1 arthrodesis	0	Very good at 18 months after removal of the P_1P_2 screws
4	25	H	Injuries at several levels of the lower limb	2 to 5	6 years 3 months	FDB/FDL transfer 2345	0	Very good at 12 months
5	42	H	Tibial pilon fracture	1 to 5	20 months	FDB/FDL transfer 2345 IP_1 arthrodesis	Asymptomatic IP_1 pseudoarthrodesis	Very good at 14 months
6	22	F	Leg fracture	2 to 5	4 years 3 months	FDB/FDL transfer 2345	0	Very good at 6 months
7	25	H	Knee dislocation, popliteal injury Calcaneal fracture	2 to 4	12 months	FDB/FDL transfer 234	0	Very good at 3 years
8	16	H	Floating knee	1 to 4	12 months	FDB/FDL transfer 234 IP_1 arthrodesis	0	Very good at 2 years
9	18	H	Leg fracture	1 to 4	3 years	FDB/FDL transfer 234 IP_1 arthrodesis	0	Very good at 1 year
10	37	F	Compound leg fracture (Fig. 2)	1 to 4	16 months	FDB/FDL transfer 234 IP_1 arthrodesis	0	Very good at 18 months

FDB: flexor digitorum brevis; FDL: flexor digitorum longus; $IP_{\&}$: interphalangeal joint of the hallux; M_1: first metatarsal; M_4: fourth metatarsal.

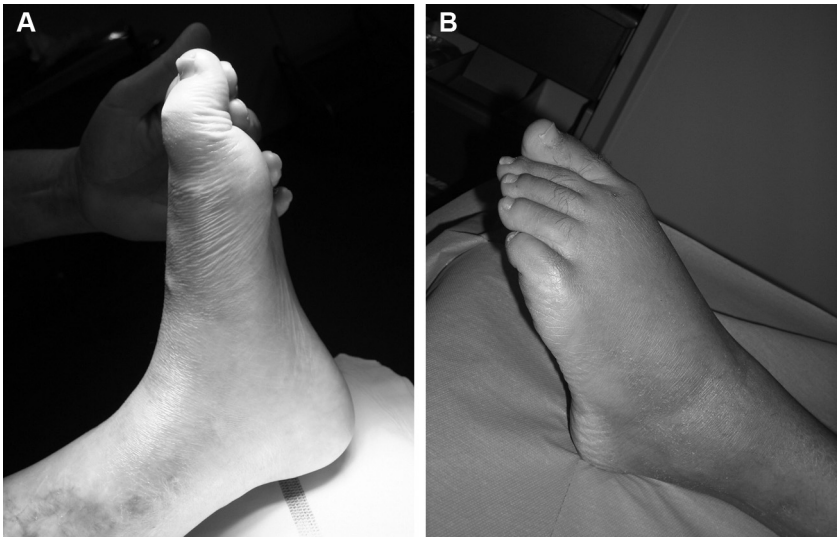

Fig. 2. A. Dorsiflexion of the ankle causes the claw toe deformity to appear. B. The claw toe deformity resolves upon plantar flexion of the ankle. Note that, in plantar flexion, which is active here, the position of the toes indicates satisfactory function of the intrinsic muscles.

absence of recurrent CTD and normal active toe flexion in all patients. No joint stiffness was noted at the treated toes. Radiographs showed pseudo-nonunion of the hallux interphalangeal joint in 1 patient, who had no symptoms and therefore did not require repeat surgery. In another patient, hallux interphalangeal arthrodesis screws that rubbed against the skin were removed.

4. Discussion

Our findings support FDB to FDL tendon transfer as described by Valtin and Leemrijse [1,2] for the treatment of CTD due to leg injuries, with isolated FDL shortening, normal intrinsic foot muscle function, and normal joint range of motion. CTD meeting all these criteria is rare, which explains the small number of patients in our study. The procedure is easy to perform, inexpensive, and suitable for outpatient care. Patient satisfaction with the outcome is high. The CTD resolves and toe flexion is recovered via restoration of FDL function.

This technique is not suitable for rigid CTD of the lesser toes or severe sequelae at the foot with concomitant impairment of the extrinsic and intrinsic muscles. The FDB to FDL tendon transfer technique described here converts the FDB to an extrinsic flexor: the FDB sutured to the FDL, in the absence of efficient interosseous or lumbrical muscles, ensures plantar flexion of the interphalangeal joints. A crucial preliminary step is therefore testing of the intrinsic flexor muscles, which must have normal function if the technique is to succeed.

The anatomy of the flexor system is different at the hallux, which can therefore not be treated in the same way. Arthrodesis with shortening of the hallux was sufficient to correct the irreducible hallux CTD in all 6 patients in our case-series, obviating the need for FHL tenotomy. The shortening should remain limited and, if the correction is inadequate, Z-plasty lengthening of the FHL is preferable over further shortening of the hallux.

The FDL may become abnormally short in two situations. One is focal and/or perifocal trapping of the tendon at the fracture site then within the callus, a rare event that has been well-described in distal leg and ankle fractures under the designation “checkrein deformity” [6,7]. The other is ischemic muscle contracture as a sequela of leg compartment syndrome [8] with full recovery except at the deep posterior leg. Some patients may have low-grade compartment syndrome that is missed initially, then continues to progress with limited symptoms. Muscle contractures take several months to develop in this situation. This presentation explains the mean time from the initial injury to CTD surgery of 34 months in our case-series.

Tenolysis procedures at the leg and posterior to the medial malleolus have been described. They seem to provide satisfactory outcomes when performed early in patients with flexor tendon entrapment in the fracture site as described above [6,9]. In other situations, isolated tenolysis of wasted muscles produced poor outcomes in studies by Valtin and Leemrijse [1,2] or Feeney et al. [10], with long-term CTD recurrence due to a return of the fibrosis about the tendons. Nevertheless, Fitoussi et al. has advocated the use of this procedure in children [11].

Isolated FDL tenotomy at the toe, which can be performed percutaneously [12], has been reported to partly correct extrinsic CTD of the lesser toes but only at the price of decreased toe flexion strength. Some patients reported difficulty walking due to insufficient push-off from the tips of the toes. This technique is suitable for congenital CTD [13,14] and in patients with concomitant palsy of the intrinsic plantar muscles. FDL lengthening yields similar outcomes, with improved function [15] but is not appropriate for CTD after leg injuries, as muscle function is lost.

All patients in our case series had flexible CTD due to FDL shortening, with normal intrinsic muscle function. We do not advocate osteo-articular procedures on the lesser rays in patients with flexible CTD: instead, arthrolysis, resection-arthroplasty, and resection-arthrodesis should be reserved for fixed deformities.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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